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ABSTRACT

This paper examines the feasibility of distributing Elementary and Secondary Education Act Title I aid among school districts according to the educational achievement of pupils in each district. The "predicted achievement method" would permit the distribution of aid on the basis of population characteristics in a way that, on average, directs more funds to communities with more low achievement pupils. Th evidence for Massachusetts indicates that the multiple regression predicted achievement method would provide a significantly better targeting of funds to low achievement districts than the current method of distributing funds according to the number of children in poverty. The first section of the paper discusses the logic of the predicted achievement method and the way that it would be implemented in practice. Section 2 describes the Massachusetts data used in the analysis. The third and fourth sections present results for mean achievement scores and low achievement scores. (Author/IRT)

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Distributing Federal Education Aid to Low Achievement Pupils: The Predicted Achievement Method

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Title I of the Elementary and Secondary Education Act is the primary form of Federal aid to students before the college level. In fiscal year 1977, the Title I program will provide grants of nearly two billion dollars to local education authorities for educational spending on low income pupils. The rules of the program and its legislative history indicate that its primary purpose is to increase the expenditure on these pupils and not to redistribute income, to equalize educational spending among districts, or to compensate communities for the difference between educational spending on low income pupils and the local taxes that their families pay either directly or indirectly.

Although the program is formally stated in terms of low income levels, some may instead regard the current method of distributing Title I funds on the basis of the number of children in poverty in each area as an indirect way of providing funds for children with low educational achievement levels.[1] In this paper I explain how the targeting

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[1] The current method of distribution also adjusts for differences among states in the cost of education. I will assume that this adjustment will be maintained in the future and will not discuss it explicitly.

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of Title I funds to low achievement pupils could be improved by using a multiple regression prediction equation. This method would make the distribution of Title I funds depend on several demographic and economic variables that are currently collected by the Census. The evidence for Massachusetts presented here indicates that the predicted achievement method can be substantially more effective than the current Title I method at directing funds in relation to achievement.

The first section of this paper discusses the logic of the predicted achievement method and the way that it would be implemented in practice. Section 2 describes the Massachusetts data used in the current analysis. The third and fourth sections present results for mean achievement scores and low achievement scores. There is a brief concluding section.

1. The Predicted Achievement Method

Consider the problem of distributing a fixed amount of Title I funds among the school districts within a state; the issues and methods that arise in this context can be extended to the more general problem of distributing national funds among the states. The goal accepted in this paper is to distribute these funds on the basis of "educational need" as measured by poor performance on standard tests of educational achievement or ability.

The most direct approach would obviously be to administer a standardized test to all students in the state and then distribute funds on the basis of the resulting test scores. I will refer to this as the "measured achievement method" to distinguish it from the "predicted achievement method" that is developed below. To be more specific, the measured achievement method might give more funds to school districts with low mean achievement scores or to school districts in which a higher proportion of students had scores below a given standard.

The obvious problem with this method is that it gives school districts an incentive to attain test scores that understate the true ability of their students. If the reward for poor performance is great, the resulting bias in reporting is also likely to be great. Test scores can be depressed by intentionally poor test conditions, by explaining to students that their school will be rewarded with extra resources if they do poorly, etc. Since poor performance is easily achieved, the resulting test scores are likely to be without value as a measure of students' true abilities. The measured achievement method must therefore be rejected as unworkable.

The predicted achievement method would also begin by administering a standardized test to all students in the state and calculating the mean score for each school district.[1] These mean achievement scores are then related by a multiple regression equation to some of the economic and demographic characteristics of the school district that are collected by the Census of Population. The estimated regression equation is used to "predict" the mean test score that each district would be "expected" to achieve on the basis of its population characteristics. Title I funds are distributed among the districts according to these predicted test scores.

The predicted achievement method is thus able to use information on test scores without giving school districts an incentive to report a biased measure. Each school district knows that the aid that it will receive will depend on its population characteristics as reported by the Census. The test scores of its students have only a very small and indirect effect on the amount of aid received through the influence that the district's test score would have on the estimated coefficients of the regression equation. With a large number of districts, the influence of any single district's score on the coefficients will be imperceptibly small and the incentive to distort can safely be ignored.[2]

The current method of distributing Title I funds on the basis of the number of pupils in poverty can be regarded as a simple form of

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[1]Other summary measures, such as the proportion scoring below some arbitrary level, might also be used. I return to this below.

[2]Even this small incentive to distort can be eliminated by giving a small reward for high measured test scores while giving substantial aid on the basis of low predicted test scores.

the predicted achievement method based on a single variable. A higher proportion of pupils in poverty is generally associated with a lower mean achievement score in the district. By making the aid per pupil that is given to a district proportional to the percentage of pupils in poverty, the current Title I program generally distributes more aid per pupil in districts with lower mean achievement scores. However, the association between the percentage of pupils in poverty and the district's mean achievement score is a relatively weak one; in the evidence for Massachusetts presented below, the correlation between these variables is -0.40. This implies that, if aid per pupil is distributed in proportion to the percentage of pupils in poverty, the correlation between per pupil aid and mean achievement will also be -0.40. By using additional population characteristics that are associated with low achievements, the multiple regression form of the predicted achievement method obtains a much closer targeting of funds; the Massachusetts evidence implies that adding four more variables increases the correlation from 0.40 to 0.60. The details of this multiple regression form and other measures of low achievement will be discussed after the data are described.

2. The Data

The predicted achievement method is illustrated in this paper with data for 310 Massachusetts school districts. The analysis combines information on individual pupil achievement test scores and ability test scores with 1970 Census information on the population characteristics of their school districts. This section describes the data and presents a few summary statistics.

In 1971, each of the school districts in Massachusetts administered the same achievement and ability tests to all of their fourth grade pupils.[1] The tests used were the McGraw-Hill Comprehensive Test of Basic Skills and the California Mental Maturity Test. Three separate achievement test scores were calculated for each pupil: reading achievement, language achievement and mathematics achievement. Although no official single summary achievement score was defined, the mean of the three individual scores will be used in this study and will be referred to as the achievement score. In addition, three ability test scores were calculated for each pupil: a verbal ability score, a non-verbal ability score and a combined ability score. The Massachusetts Department of Education provided a computer tape with these test scores for each of the 80,814 fourth grade pupils in the state.

The analysis in this paper will focus on the two summary scores: the combined achievement score and the overall ability score. For each

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[1] Although it would obviously have been better if test scores were available for all grades, the current data are sufficient for the present illustrative purpose.

score, two different types of measure of poor achievement are considered: the mean score in the school district and the percentage of pupils scoring below various "low score" thresholds. These measures of poor achievement were calculated for the 310 Massachusetts school districts for which Census information could also be collected; these districts include 87 percent of the Massachusetts population.

Table 1 presents state summaries of the achievement and ability measures for the 310 school districts. The achievement test is scored to produce a national average of 400. The average of the Massachusetts district scores is 423.2. District averages ranged from a low of 364.5 to a high of 464.4. It must be borne in mind that these scores are district means of individual pupil scores; there would, of course, be much more variation among individual pupil scores. The second row of the table shows that on average 24.3 percent of the pupils in a school district scored below 390. The percentage of low scoring pupils (by the 390 criterion) varied widely; the minimum and maximum values imply that in at least one district no pupil scored below 390 while in another more than 80 percent were low scorers. The next two lines of the table show corresponding summaries for two lower achievement standards.

The ability test is scored to produce a national average of 100. In Massachusetts, the mean of the district averages was 107.0. The other figures presented in lines 5 through 8 of Table 1 can be interpreted like the achievement score summaries in the top part of the table.

The basic population characteristics that are likely to affect pupil achievement and ability scores are the education and income of the parents in the school district. Other possible influences include the

Table 1

School District Test Scores and Population Characteristics

	State Mean of Districts	Standard Deviation	Minimum	Maximum
Achievement Score				
1. District Average	423.2	14.5	364.5	464.4
2. Percent below 390	24.3	12.2	0.0	81.8
3. Percent below 370	13.1	8.9	0.0	48.5
4. Percent below 350	6.5	5.9	0.0	33.3
Ability Score				
5. District Average	107.0	4.0	92.8	116.2
6. Percent below 95	18.4	9.5	0.0	51.5
7. Percent below 90	9.7	6.7	0.0	45.5
8. Percent below 85	4.4	4.0	0.0	25.0
Population Characteristics				
9. School Children in Poverty (%)	7.3	6.1	0.0	59.2
10. Families with High Income (%)	5.9	6.3	0.0	46.2
11. Families with Low Income (%)	27.3	9.8	6.6	63.4
12. Adults with High School Diploma (%)	61.8	13.8	25.6	90.4
13. Adults with Any College (%)	26.3	13.1	0.0	64.9
14. Children per Family	0.95	0.19	0.46	1.58

Statistics refer to 310 Massachusetts school districts in 1971; see text for further explanation.

number of children per family, the size of the community, and the occupational mix of the population.[1] Since school districts in Massachusetts have the same boundaries as towns and cities, Census data for individual districts are available for all districts above a very small minimum size. As noted above, the 310 districts used in this study include 87 percent of the state population.

The percentage of school children from families below the poverty line corresponds approximately to the poverty criterion used by the current Title I formula. For the 310 Massachusetts towns, an average of 7.3 percent of children age 6 to 17 were in families below the poverty line. Line 9 of Table 1 provides other measures of the distribution of this variable.

Although the percentage of children from poverty families may be the best single measure of income to use in predicting low achievement and ability scores, the predictions can be improved by using additional measures of the district's income distribution.[2] The equations presented below use the percentage of "high income" families (i.e., families with incomes above $25,000 in 1969) and the percentage of "low income" families (i.e., families with incomes below $8,000 in 1969). The state averages and distributions of these variables are shown in lines 10 and

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[1] In Massachusetts there are too few districts with substantial numbers of non-white pupils or Spanish-speaking pupils to examine the influence of these factors.

[2] Note that the Census information relates to all children while test scores are for fourth grade pupils only. For an actual application of the predicted achievement method, it would obviously be desirable to have test scores for all grades. Similarly, it would be good if possible to have Census information on families with school age children rather than all families.

11 of Table 1.

Parental education is likely to have a positive effect on pupils' achievement scores. Two measures of the education of the adult population of the community are included in the prediction equations presented below: the percentage of adults over age 25 who are high school graduates and the percentage of adults over age 25 who have had any college education. More detailed measures of education, e.g., distinguishing those with a college degree from those with any college education, did not improve the statistical prediction equation.

A large number of children per family can be expected to lower pupils' mean achievement scores. An increase in family size reduces both the financial resources and parents' time available per child. The evidence presented below supports this presumption.

The other variables that were studied, including the size of the community and the occupational structure, were not statistically significant. It may of course be possible to find yet other variables that are important, especially when test scores are available for children of all ages. But the current set of income, education and family size variables is sufficient to illustrate the potential use of the predicted achievement measure.

3. Distribution According to Mean Achievement and Ability Scores

This section considers the implication of distributing Title I funds on the basis of the districts' mean achievement or ability scores. More specifically, let A_i be the number of dollars of aid per pupil given to school district i and let S_i be the measured average score on the achievement test. The "measured ability method" of distributing Title I funds could take the form:

$$(1) \qquad A_i = a_0 - a_1 S_i .$$

The parameters of this formula (a_0 and a_1) must be chosen in a way that is consistent with the available Title I aid per pupil for the state as a whole, $\bar{A}$. Since equation 1 implies that $\bar{A} = a_0 - a_1 \bar{S}$ where $\bar{S}$ is the average score in the state,[1] equation 1 can be rewritten as

$$(2) \qquad A_i = \bar{A} - a_1 (S_i - \bar{S}) .$$

A district's aid per pupil is equal to the available average aid per pupil ($\bar{A}$) plus or minus an amount that depends on the difference between the average score in the district and the state average score. The parameter a_1 could be chosen to make the distribution of aid as sensitive or insensitive to S_i as the policy officials wish. If this method were workable, it would provide perfect targeting of funds to districts with low mean achievement; i.e., the correlation of A_i and S_i would be exactly minus 1.

As I explained in section 1, this measured achievement method is not workable because of the incentive that it contains for distorted

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[1] Note that $\bar{A}$ and $\bar{S}$ are weighted averages of A_i and S_i, weighting by the corresponding numbers of pupils.

measurement of S_i. The predicted achievement method can be operated in an exactly similar way without the incentive for distorted measurement of S_i. In place of equation 1, the aid formula is

$$(3) \qquad A_i = a_0 - a_1 SP_i$$

where SP_i is the score predicted for district i on the basis of the multiple regression equation and a_0 is chosen to satisfy the Title I budget constraint.[1] Since the actual and predicted scores are not equal, the targeting of aid according to score will be less accurate than it would be if the S_i could be used directly. More precisely, the correlation between aid and actual score if equation 3 is used as the aid formula is equal to the correlation between SP_i and S_i in the regression equation.

Table 2 presents the equations relating the mean achievement and ability scores in each district to the five income and education variables described above. For comparison with the implications of the current method, equations are also presented in which the percentage of school children below the poverty line is the only independent variable.

Equation 2.1 shows that the district mean achievement scores respond in the anticipated ways to all five independent variables. A district tends to have lower achievement scores when a higher percentage of children are in families below the poverty line, when a higher percentage of families have incomes below $8000, and when there are more children per family. Note that although the two measures of

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[1] Equation 2 cannot be used here because the weighted average of the SP_i is not equal to $\bar{S}$.

Table 2

Equations Predicting Mean Achievement and Ability Scores

Equation	Dependent Variable	Independent Variables: Children in Poverty	Low Income Families	High Income Families	High School Graduates	College Attendees	Children Per Family	Constant	R
2.1	Mean Achievement	-0.558 (0.125)	-0.286 (0.108)	0.192 (0.188)	0.274 (0.119)	0.065 (0.149)	-11.2 (4.6)	426.0	0.595
2.2	Mean Achievement	-0.961 (0.124)						430.3	0.404
2.3	Mean Ability	-0.190 (0.028)	-0.059 (0.025)	0.038 (0.043)	0.049 (0.027)	0.098 (0.034)	-3.3 (1.1)	107.4	0.735
2.4	Mean Ability	-0.315 (0.032)						109.3	0.485

See text for definitions. Standard errors are shown in parentheses.

income are obviously correlated, there is sufficient independent variation to make both of them statistically significant and useful variables in the equation. The regression coefficients also indicate that districts tend to have higher achievement scores when a higher percentage of adults are high school graduates and have had some college education; more families with high income raise the district mean score but the effect is not statistically significant.

As I indicated above, the individual regression coefficients are less important for the current purpose than the goodness of fit of the equation as a whole. The multiple correlation coefficient of $R = 0.60$ implies that the correlation between the 310 measured mean achievement scores and the corresponding mean achievement scores predicted by equation 2.1 is 0.60. This in turn implies that if Title I funds are distributed according to the predicted achievement formula of equation 3, the correlation of aid per pupil and actual score will be -0.60. This is true no matter how intensely aid is made to respond to predicted score as long as a_i is not equal to zero.

The current method of distributing Title I aid in proportion to the number of children in poverty is exactly equivalent to using a form of equation 3 but basing the predicted score on a regression using the percentage of children in poverty as the only variable. Distributing Title I aid in proportion to the number of children in poverty implies

$$A_i N_i = k \, POV_i \,, \tag{4}$$

i.e., the total aid received by the district ($A_i N_i$) is k dollars per pupil in poverty (POV_i). This is clearly equivalent to

$$(5) \qquad A_i = k\left(\frac{POV_i}{N_i}\right) ;$$

aid per pupil is proportional to the percentage of pupils in poverty. A regression equation relating predicted score to the poverty percentage can be written

$$(6) \qquad SP_i = \beta_0 - \beta_1\left(\frac{POV_i}{N_i}\right)$$

where β_0 and β_1 are the estimated regression coefficients. Substitute 6 into 3 to obtain a distribution formula based on predicted achievement:

$$(7) \qquad A_i = a_0 - a_1\beta_0 + a_1\beta_1\left(\frac{POV_i}{N_i}\right) .$$

By choosing a_0 and a_1 to make $a_0 - a_1\beta_0 = 0$ and $a_1\beta_1 = k$, equation 7 is identical to the current rule as expressed by equation 5.

Equation 2.2 of Table 2 presents the regression coefficients for predicted achievement based on the percentage of children in poverty. The correlation coefficient is only R = 0.40. This implies that the correlation between aid per pupil and average score is only -0.40 with the current method of distributing aid in proportion to the number of children in poverty. The multiple regression method of equation 2.1, with its correlation of 0.60, is clearly more successful at targeting aid to districts with low average achievement.

It is worth noting that the distribution of funds differs substantially between the two methods. The correlation between the aid per pupil that would be distributed on the basis of equation 2.1 and the aid per pupil that is distributed in proportion to the percentage of pupils in

poverty is only 0.68.

Equations 2.3 and 2.4 of Table 2 present the corresponding coefficients for the predicted ability equations. Again the multiple regression equation can provide substantially better targeting of aid than the distribution in proportion to the percentage of children in poverty.[1]

[1]Appendix Table A-1 presents equations corresponding to 2.1 and 2.3 for the individual components of the achievement and ability tests.

4. Distribution According to Low Score Proportions

Although the mean score of the pupils in a district is the most natural summary of the test scores of all of the pupils, it may be more appropriate to focus Title I aid on districts with larger numbers of low scoring pupils and to disregard high scorers. If so, the mean score is a less suitable criterion than the proportion of pupils with scores below certain levels. This section examines the feasibility of using multiple regression equations to predict the proportion of pupils with low scores. Table 1 above showed the average proportions falling below the thresholds that will be used for the achievement and ability tests.

The aid formula now takes the form

$$(8) \qquad A_i = b_0 + b_1 \, PPB390$$

where PPB390 is the predicted percentage of pupils scoring below 390 on the achievement test. Analogous distribution equations could be written for the other thresholds and for the ability scores.

Since the interpretation and properties of this equation are essentially identical with the analysis of section 3, we can turn directly to the results presented in Table 3. Column 1 indicates the dependent variable for each equation and column 2 reports the mean of that variable for the state as a whole. The multiple correlation coefficient reported in column 10 is also equal to the correlation between aid per pupil and the percentage of pupils below the critical threshold if aid is distributed on the basis of the predicted proportion of low-scoring pupils. For comparison column 11 presents the correlation between the percentage of pupils below the critical threshold and the percentage of children in

Table 3

Equations Predicting Proportion of Pupils with Low Achievement and Ability Scores

uation	Dependent Variable	Independent Variables: Children in Poverty	Low Income Families	High Income Families	High School Graduates	College Attendees	Children Per Family	Constant	R	Correlation of Dependent Variable with Children = Poverty
3.1	Achievement below 390 (%)	0.611 (0.111)	0.295 (0.096)	-0.152 (0.167)	-0.152 (0.106)	0.009 (0.132)	14.7 (4.1)	7.91	0.531	0.414
3.2	Achievement below 370 (%)	0.335 (0.086)	0.202 (0.074)	-0.093 (0.129)	-0.114 (0.082)	0.031 (0.102)	8.9 (3.2)	3.50	0.440	0.331
3.3	Achievement below 350 (%)	0.162 (0.059)	0.140 (0.051)	-0.073 (0.089)	-0.049 (0.057)	0.037 (0.071)	4.6 (2.2)	-0.32	0.350	0.259
3.4	Ability below 95 (%)	0.633 (0.079)	0.120 (0.068)	-0.061 (0.119)	-0.076 (0.076)	-0.123 (0.094)	7.0 (2.9)	12.21	0.622	0.522
3.5	Ability below 90 (%)	0.423 (0.576)	0.128 (0.050)	-0.033 (0.087)	-0.066 (0.055)	-0.051 (0.069)	6.3 (2.1)	2.75	0.595	0.498
3.6	Ability below 85 (%)	0.098 (0.039)	0.108 (0.034)	-0.038 (0.058)	-0.068 (0.037)	0.035 (0.046)	2.8 (1.4)	1.56	0.421	0.284

poverty; this correlation is also the correlation between aid per pupil and the percentage of pupils below the critical threshold when aid is distributed in proportion to the number of children in poverty.

Four conclusions emerge from Table 3. First, the multiple regression method always results in a substantially better targeting of aid to low-scoring pupils than the current method of distributing aid in proportion to the number of children in poverty. Second, the correlation values are lower than for the mean scores discussed in section 2: it is easier to target funds to districts with lower mean scores than to target funds to districts with a high percentage of low-scoring pupils. Third, the problem of targeting becomes more difficult as the critical score is lowered, i.e., as attention focuses on smaller and smaller fractions of all pupils. Fourth, the relative gain from using the multiple regression method becomes greater as the critical score is lowered.

5. Conclusion

This paper has examined the feasibility of distributing Federal aid among school districts according to the educational achievement of pupils in each district. I began with the very negative conclusion that it would be impossible to give aid to districts directly on the basis of low test scores because doing so would induce districts to distort the scores that they obtain and report. However, the indirect "predicted achievement method" is potentially free of such distortion. It would permit the distribution of aid on the basis of population characteristics in a way that, on average, directs more funds to communities with more low achievement pupils. The evidence for Massachusetts that is analyzed in this paper indicates that the multiple regression predicted achievement method would provide a significantly better targeting of funds to low achievement districts than the current method of distributing funds according to the number of children in poverty.